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RECENT DEVELOPMENTS IN CANADIAN NUCLEAR POWER PLANT LICENSING PRACTICES

by

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RÉSUMÉ

Cet exposé examine les facteurs qui ont marqué de façon particulière le processus d'évaluation de la sûreté des centrales de type 600 MW(e). Il décrit les changements qui pourraient être apportés à ce processus dans le cas où une décision serait prise de construire une deuxième centrale à Point Lepreau. Ces changements reposent sur une entente détaillée et documentée des exigences de la CCEA et des engagements pris par le requérant pour satisfaire ces exigences. Les progrès accomplis à ce jour concernant la formulation d'une telle entente pour Point Lepreau 2 sont également décrits.

RECENT DEVELOPMENTS IN CANADIAN NUCLEAR POWER PLANT LICENSING PRACTICES

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ABSTRACT

This paper examines the dominant factors which have influenced the safety evaluation and licensing process of current 600 MW reactors. It describes possible modifications to the process which are being considered for the licensing of a second 600 MW reactor at Point Lepreau. The key element is a firm licensing agreement covering the entire licensing cycle, to be established between the proponent and the AECB before a construction licence is issued. Progress accomplished to date in reaching such an agreement is described.

INTRODUCTION

Although only one basic reactor type has been developed in Canada during the last 25 years, currently licensed power stations exhibit significant design differences as illustrated by Table 1. To date, no station has been licensed for construction as an exact replica of an operating station.

These differences in plant design have been accommodated by the Canadian licensing approach which has emphasized basic performance requirements, and which has allowed a large amount of overlap between the completion of design and analyses on one hand, and construction on the other. These characteristics of our licensing approach have had advantages for both the licensees and the regulator. They also had certain disadvantages.

Changes that could be made to our safety evaluation and licensing process to remove some of the difficulties experienced in the past have been considered since 1983 in the context of licensing a second 600 MW station at Point Lepreau. Before describing these changes, however, it is useful to briefly review the licensing history of existing 600 MW stations, to identify areas where significant improvements can be achieved. It should be noted that, while the discussion in this paper focuses on 600 MW stations, the general change in direction which is described could also apply to other types of CANDU stations which have recently been licensed for operation.

A BRIEF REVIEW OF THE LICENSING HISTORY OF EXISTING 600 MW PLANTS

Since the duration of the construction and licensing process is an important element in this discussion, some key dates of the Gentilly-2 and Point Lepreau 1 history should be mentioned. Gentilly-2 construction licence was issued in 1974. At that time, the expected start-up date was 1978. Point Lepreau 1 received its construction licence in 1975. The two plants received their operating licences in 1982.

A review of the experience gained during the licensing of Gentilly-2 and Point Lepreau 1 shows that between 1974 and 1982, the development of the licensing process for these two plants was influenced by three dominant factors:

(a) Evolution in plant design;
(b) Evolution in licensing requirements; and
(c) Communications between the AECB and the licensees.

Each one of them will be considered briefly.

Evolution in Plant Design

Since there have been numerous interactions between the evolution of plant design and the evolution in AECB requirements, let us consider, first, those changes which had to be made solely as a result of the design finalization process rather than as a result of new or evolving regulatory requirements. A number of important design changes made during the construction phase of Gentilly-2 and Point Lepreau 1 can be classified in this category (Figure 1).

The evolution of the Gentilly-2 and Point Lepreau 1 Emergency Core Cooling (ECC) system is an excellent example. The system proposed in support of the construction licence applications was a low-pressure system whose exact configuration (the injection points in particular) had not been finalized when the construction licences were issued. At that time, a very limited amount of analysis had been done to assess the effectiveness of the system. It was only in 1976 that it became evident to the designers that a low pressure system would not be sufficiently effective to limit radioactive releases to within the regulatory dose limits. Investigation of the likely effectiveness of a high pressure ECC system was undertaken and a decision to install the high pressure system was subsequently taken by Hydro-Quebec and NBEPC.

Although the modification of the ECC system design is undoubtedly one of the most important in this category, other changes made during the construction phases of Gentilly-2 and Point Lepreau 1 can also be attributed solely to design finalization. Examples include:

(a) the installation of reactor outlet header interconnects to eliminate potential pressure and flow oscillations in the primary heat transport system;

(b) the incorporation of Programmable Digital Comparators (PDC's) in shutdown systems to permit complex conditioning of trip setpoints (this was necessary for some parameters where the conditioning function could not be performed reliably by analog equipment); and

(c) the change from an open-loop to a closed-loop service water system at Gentilly-2.

When such major modifications become necessary at a late stage of the construction phase, conflicts between analytical, design and procurement programs are usually unavoidable. The impact on project schedule as well as on licensing activities can be severe. Further complications can arise if major modifications must be made when most plant equipment has been installed and even commissioned.

Evolution in Licensing Requirements

Let us now consider the second factor: "evolution in licensing requirements". Again, it should be emphasized that the purpose of this paper is not to do a comprehensive review of this evolutionary process but rather to highlight areas where past experience might play an important role in determining the appropriateness of any change in direction in the future.

In the early 1970's, it became evident, with the increased complexity of nuclear power plants and the accumulated operating experience, that the traditional single/dual failure analyses were no longer sufficient by themselves, to fully and properly assess the overall safety of the plant. When construction licences were issued for Gentilly-2 and Point Lepreau 1, the need to do a more systematic review of the plant had already been identified and discussions were held with the licensees to define acceptable means of addressing topics such as:

(a) the treatment of safety support functions in analyses;

(b) the treatment of long-term effects of some accidents;

(c) the treatment of events which do not require immediate safety system response, but rather an orderly set of corrective actions either automatic or operator-initiated; and

(d) the treatment of common-cause events which could disable or incapacitate more than one process or safety system.

Certain design features were proposed and committed by the licensees very early in the construction phase to improve the safety of the plant in some of those areas. The physical separation of safety systems into two independent groups, the addition of an auxiliary control area, and the addition of the emergency water system and emergency power system are examples of these features. However, not all the necessary or desirable design changes could be identified early in the construction phase. As part of the more thorough safety evaluation process, a number of new safety analyses had to be undertaken to confirm the adequacy of the design and to predict system behaviour and system interactions under a wide range of abnormal conditions. As these analyses were completed during the construction phase of the plants, the need for several additional design modifications was recognized and these modifications were implemented at various points in the project schedules (Figure 1). Examples of some significant modifications include:

(a) the addition of a second auxiliary boiler feed pump (to increase the reliability of the feedwater supply);

(b) the addition of local air reservoirs for the pneumatically-operated primary heat transport system liquid relief valves (to prevent loss of PHT inventory in the event of a loss of instrument air);

(c) the provision of back-up cooling water supplies to the instrument air compressors (to eliminate the cross-link between the service water and instrument air systems); and

(d) the reduction of the water volume in the dousing tank (to prevent flooding essential instrumentation in the reactor building basement).

Occasionally, licensees have expressed the view that, at times, design modifications had to be made during the construction phase of previous plants only to satisfy new or evolving licensing requirements, and that these modifications had adverse effects on project schedules and costs. The type of changes that we have just discussed are probably the best candidates for generating a very interesting "chicken or egg" debate on what comes first: "evolving licensing requirements" or "evolving design". Would we have required the addition of a second auxiliary boiler feed pump at Gentilly-2 and Point Lepreau 1, for example, if the utilities had not decided to proceed with this modification? Based on the information which was submitted in the loss-of-feedwater analysis, there is no doubt that we would have raised the issue. The addition of a second auxiliary boiler feed pump was considered to be an adequate solution to the shortcoming which had been identified. Whether it should be considered to be a firm licensing requirement or whether it is something which a prudent operator would have required is another matter. The licensees might have proposed a different solution which would have been equally acceptable. In other cases, however, the design options seem so obvious or so limited that changes made during the construction phase of previous plants can essentially be considered as licensing requirements. My conclusion is that the evolution of plant design and the evolution of the detailed licensing requirements have interacted so extensively that it is sometimes very difficult to distinguish between those changes which can be attributed to new regulatory requirements and those which were dictated by information which became available as the design or analyses were finalized.

Nevertheless, we do not deny the fact that some changes were made in Gentilly-2 and Point Lepreau 1 as a result of new regulatory requirements (Figure 1). The addition of a trip parameter on shutdown system No.1, to provide better protection against loss of service water accidents, is an example of such a requirement. Finally, it should be noted that other new regulatory requirements have been formulated and documented before Gentilly-2 and Point Lepreau 1 were granted an operating licence but have not been imposed on these stations (Figure 1). This point will be discussed later in this paper.

Communications Between the AECB and the Licensees

The last factor which, in my view, has affected the licensing process of previous 600MW plants is the communication between the regulator and the licensees. In general, communications between the regulator and the licensees have been good. A

review of the major licensing issues which were still unresolved one year preceding the issue of the Gentilly-2 and Point Lepreau 1 operating licences reveals however that certain licensing difficulties can only be attributed to a lack of communication between the regulator and the licensees. Most of these problem areas related to aspects of safety analyses such as the clear identification of licensing basis cases, acceptability of assumptions used in analyses, and documentation requirements. Specific examples where timely agreements were not reached include:

(a) the need to analyze loss-of-coolant accidents with class IV power unavailable; and

(b) assumptions regarding the degree of dousing impairment to be assumed for dual accidents involving failures in the primary heat transport system.

The conclusions which can be drawn from this necessarily brief review of the licensing history of Gentilly-2 and Point Lepreau 1 are:

1. These plants were the first 600MW to go through the safety evaluation and licensing process. When construction licences were issued in 1974 and 1975, the design of many systems had not been finalized.

2. When construction licences were issued in 1974 and 1975, only a limited number of preliminary analyses had been done and, except for the classical single/dual failure type of analyses, regulatory requirements in this area were very much in a developmental stage.

3. Some communication difficulties between the regulators and the licensees persisted until a fairly late stage in the project schedule.

4. The above-mentioned considerations all contributed to delaying the submission of licensing documentation, thereby shifting the AECB licensing workload towards the latter part of the construction phase (Figure 2). From a regulator's point of view, this is very undesirable, since the review of documentation and resolution of licensing difficulties at this stage inevitably conflicts with other Board staff responsibilities, especially those relating to plant commissioning.

A GENERAL DESCRIPTION OF THE MODIFICATIONS CONSIDERED IN THE SAFETY EVALUATION AND LICENSING PROCESS

In 1983, when feasibility studies for the Point Lepreau 2 project were sufficiently advanced, a series of discussions between the proponent (AECL and NBEPC) and the AECB was undertaken to identify the licensing requirements that would apply to that project. These discussions led the two parties to conclude that the 600MW plant had probably reached a stage of maturity sufficient to justify the introduction of certain changes in the safety evaluation and licensing process. It was considered that the experience gained during the licensing, commissioning and operation of Gentilly-2 and Point Lepreau 1 would allow a more complete and precise identification of licensing requirements in the early stage in the licensing process for a repeat unit. A much larger proportion of the required licensing documentation could also be submitted at a very early stage.

On that basis, it was concluded that an agreement could be established between the proponent and the AECB whereby the proponent would have an obligation to complete all licensing actions in the agreed manner and the AECB would have an obligation to judge the acceptability of the licensing submissions against the detailed criteria established. The licensing requirements would remain essentially fixed throughout the remainder of the licensing process, except of course that provisions would be made for situations where new experimental or analytical information or operating experience at other stations revealed significant inadequacies in the design of the new station being considered.

The reason why the AECB would accept to enter into such an agreement with a proponent is certainly a legitimate question. Basically, the answer is that the agreement is seen as a valuable tool for reversing the trend described in Figure 2 where a large fraction of the licensing submissions and regulatory review end up being concentrated in the late phase of the licensing process. This characteristic has not been unique to the 600 MW reactors. On the contrary, it has been present on all plants licensed to date, and attempts at improving this situation have not been very successful. From our point of view, therefore, the main benefit which is expected from this modification to our licensing practices is a regularization of the licensing activities throughout the entire process. The result, we believe, will be that the safety evaluation and licensing of this future plant should proceed in a more effective and orderly manner. This objective, of course, is shared by the proponent. In the case of Point Lepreau 2, the proponent also has other incentives for wishing to ensure that the licensing process proceeds without difficulties. These aspects will be discussed further in another paper presented during this session by Mr. Natalizio.

For the proposed approach to be effective, the licensing basis agreement obviously has to cover all areas which must be addressed throughout the entire safety evaluation and licensing process. The most important of these are listed in table 2. As expected, our experience to date has confirmed that reaching firm licensing agreements can be fairly straightforward in some areas and rather complicated and time consuming in others. So far, our efforts have been concentrated in two areas: plant design, and safety analysis requirements. These topics are discussed further below.

Plant Design

Before reaching a firm licensing agreement on the design of a future 600MW plant, a careful review of the design of current plants must be carried out and consideration must be given to those regulatory requirements which have evolved throughout the licensing phase of previous plants but which, for one reason or another, have not been incorporated into those plants. The requirements which are documented in our proposed regulatory guides C-7, C-8 and C-9 (references 1-3), which were not applied to previous 600 MW plants, are particularly important in this regard.

While the review of design requirements to be incorporated in the licensing agreement is still ongoing, some preliminary conclusions are worth mentioning:

(a) to minimize the potential consequences of boiler tube failures or the consequences of loss-of-coolant accidents occuring when boiler tube leakage already exists, AECB staff considers that the design of future stations should incorporate isolating valves on the main steam lines. This design modification would meet the intent of section 1.2 of our regulatory guide C-7 for a continuous containment envelope;

(b) the design of the 600 MW Emergency Core Cooling System needs to be further reviewed, especially with respect to control room panel layout and long-term reliability. A number of design changes may be required as a result of these considerations;

(c) consideration will have to be given to modifying the instrument room layout for shutdown system No.2 in order to improve channel separation in that area.

In addition to the above, it should be noted that during the licensing of previous 600MW plants, certain design modifications were committed but, with the acceptance of the AECB, they have not yet been implemented in Gentilly-2 and Point Lepreau 1. One important commitment relates to modifications aimed at reducing the dependence on natural circulation of primary coolant in some accident situations. Clearly, such commitments will have to form part of the licensing basis agreement for a future plant.

One final comment needs to be made on the question of design change requirements. The licensing basis agreement which is being established between AECL/NBEPC and the AECB is specific to Point Lepreau 2. Thus, there could be some design modifications which would be considered mandatory for a new 600 MW station on a new site, but which will not necessarily form part of the Point Lepreau 2 agreement. The reason for this is that from an operational safety point of view, consideration has to be given to possible disadvantages associated with having different design features at the same site or even in the same control room.

Safety Anaylsis Requirements

With respect to safety analyses, experience to date has shown that the definition, at the pre-construction licence phase, of commitments relating to the execution, submission and acceptance of all analyses needed to support a request for an operating licence, is indeed a challenging task, both for the proponent and the regulator. For the licensing agreement to be meaningful, the scope of the analytical program, as well as the proposed analytical techniques and assumptions, need to be defined very clearly for each analysis to be performed.

As for plant design, the conclusion of a firm agreement must also take into account the evolution of regulatory requirements that has occurred during the licensing of previous plants. Safety Design Matrices, for example, have played a major role in the licensing process of Gentilly-2 and Point Lepreau 1. Some shortcomings in those analyses have been identified, the resolution of which has not in every case been considered prerequisite to the issuance of operating licences for these plants. For a future plant, appropriate commitments would have to be made to correct these deficiencies.

The evolution of AECB requirements relating to safety analyses has not taken place in the context of the 600MW licensing process alone. For the Darlington station, which is presently under construction, the requirements of Consultative Document C-6 (Reference 4) are being applied on a trial basis. While we recognize that a number of adjustments will have to be made to that document, based among other things on the results of the Darlington experience, we consider that the intent of that document has to be reflected in the licensing basis agreement of any future plant. One fundamental requirement of this document concerns the need to identify the failure modes to be analysed, and to justify the selection of these failure modes on the basis of a systematic review of the plant design. The method used to carry out such a systematic review will be, of course, an important element of the licensing basis agreement. Many of the events or combination of events identified by this review process will have been analysed already for previous 600 MW plants.The resubmission of the same analyses for a new 600 MW plant could be acceptable as long as they can be documented in such a way as to demonstrate compliance with the requirements defined in the licensing basis agreement.

Finally, it should be noted that certain analyses have been accepted for previous 600MW plants but are subject to updating when new information and advances in technology provide the necessary tools to do so. The licensing agreement will obviously have to take this aspect into account.

CONCLUSION

One of the main characteristics of the modified licensing approach being developed for Point Lepreau 2 is that it places an onus on both the proponent and regulator to ensure that the requirements of the entire licensing cycle are identified clearly prior to the issuance of a construction licence. This means that the proponent must describe his intentions with respect to all licensing submissions and the AECB staff must examine these intentions to a far greater level of detail than heretofore required at that stage. Only in this way can both parties enter into firm agreements with the confidence that no misunderstandings or unacceptable positions are contained therein.

While agreements can be reached relatively easily on certain topics, others such as those relating to the preparation of safety analyses are more complex. Reaching agreement on them is also very time consuming. The experience gained to date in the context of the Point Lepreau 2 agreement has shown that the effort required by the two parties is in fact greater than originally envisaged. However, we still believe that the fundamental conclusion reached in 1983 that enough experience and information existed to make this agreement possible was a sound conclusion. Consequently, we are prepared to devote further efforts to this task and we are hopeful that these efforts will be rewarded.

REFERENCES

1. AECB Consultative Document C7 (Rev.1): "Requirements for Containment Systems for CANDU Nuclear Power Plants".

2. AECB Consultative Document C8 (Rev.1): "Requirements for Shutdown Systems for CANDU Nuclear Power Plants".

3. AECB Consultative Document C9 (Rev.1): "Requirements for Emergency Core Cooling Systems for CANDU Nuclear Power Plants".

4. AECB Consultative Document C6: "Requirements for the Safety Analysis of CANDU Nuclear Power Plants".

TABLE 1: COMPARISON OF CANADIAN NUCLEAR GENERATING STATIONS

	Pickering A	Bruce A	Pickering B	Bruce B	600 MW's	Darlington
ELECTRICAL OUTPUT (MWe)	515	740	516	750	640	881
No OF CHANNELS	390	480	380	480	380	480
REACTIVITY MECHANISMS						
- Adjuster Rods	18 (cobalt)	-	21 (SS & Cobalt)	24 (cobalt)	21 (SS & Cobalt)	24 (SS)
- Booster Rods	-	16	-	-	-	-
- Control Absorbers	-	4	4	4	4	4
- Vertical Flux Assemblies	8	20	34	27	26	27
- Horizontal Flux Assemblies	-	3	25	8	7	14
SAFETY SYSTEMS						
- SDS1 (No of S.O. Rods)	11 (+ mod. dump)	30	28	32	28	32
- SDS2 (Poison Injec. Nozzles)	-	7	6	8	6	8
- ECC (Low Pressure vs High Pressure)	L. Press. from Mod (1)	L. Press. from Dous. (1)	H. Press. (water storage tk)	H. Press. (water storage tk)	H. Press. (accumulator tks)	H. Press. (from high press. pump system)
- Containment	Vacuum-Type	Vacuum-Type	Vacuum-Type	Vacuum-Type	Pressurized Type	Vacuum-Type
HEAT TRANSPORT SYSTEM						
- Configuration (2 Loop vs 1 L)	2	1	2	1	2	2
- No Steam Generators	12	8	12	8	4	4
- No Pumps	12 + 4 spare	4	12 + 4 spare	4	4	4
- Pressure Control	Feed & Bleed	Pressurizer	Feed & Bleed	Pressurizer	Pressurizer	Pressurizer

(1) High P.ECC being backfitted

TABLE 2: LICENSING BASIS AGREEMENT

1. PLANT DESIGN
2. SAFETY ANALYSES AND ACCEPTANCE CRITERIA
3. CODES AND STANDARDS
4. SYSTEM CLASSIFICATION
5. GEOLOGY AND SEISMICITY
6. QUALITY ASSURANCE PROGRAMS
   (DESIGN, PROCUREMENT, CONSTRUCTION, COMMISSIONING, OPERATION)
7. COMMISSIONING PROGRAM
8. STAFFING AND TRAINING PLANS
9. SECURITY PLAN
10. DOCUMENTATION ON PLANT OPERATION
11. SCHEDULE FOR SUBMISSION OF LICENSING INFORMATION
12. REGISTER OF LICENSING DOCUMENTATION.

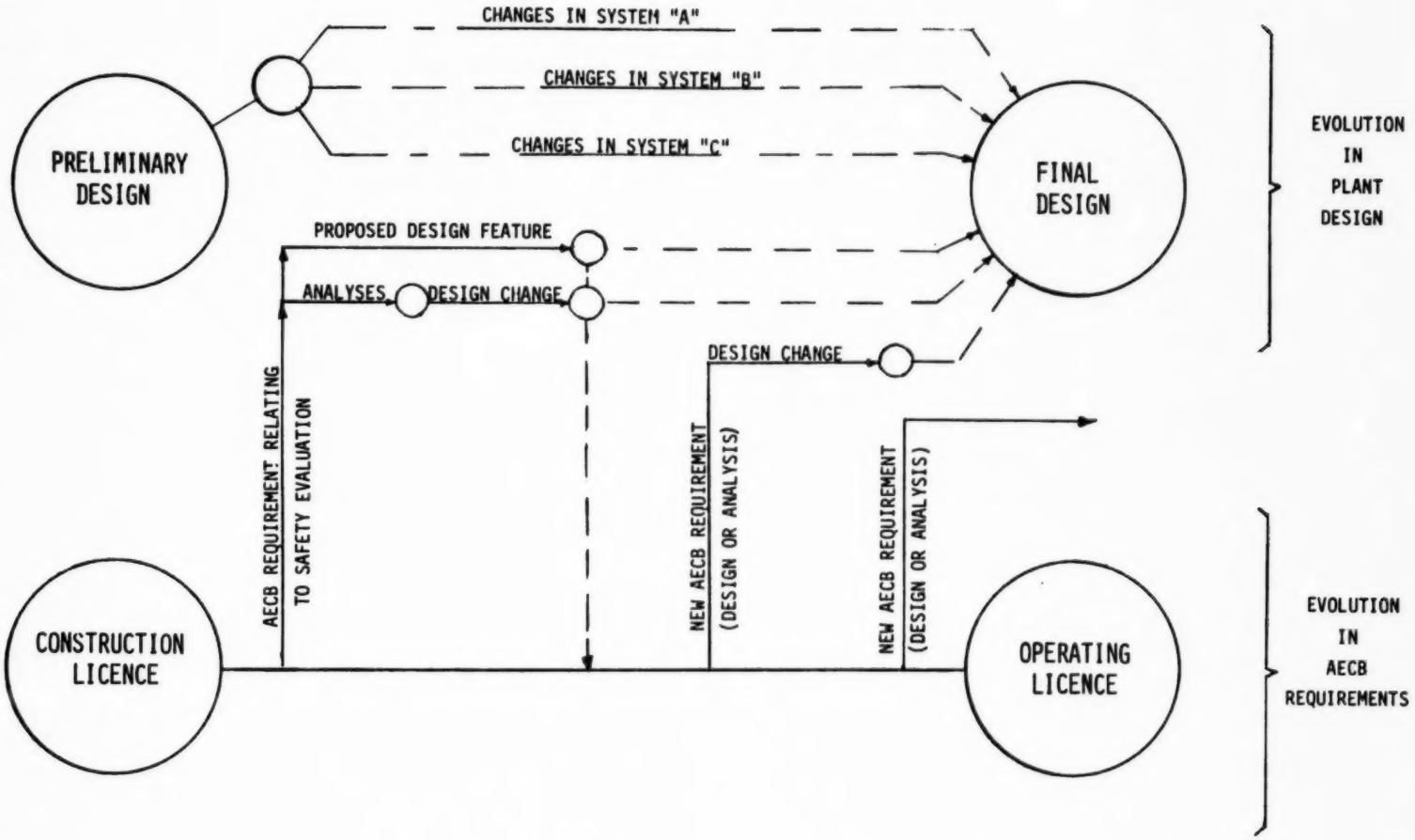

FIGURE 1: EVOLUTION IN PLANT DESIGN AND AECB REQUIREMENTS

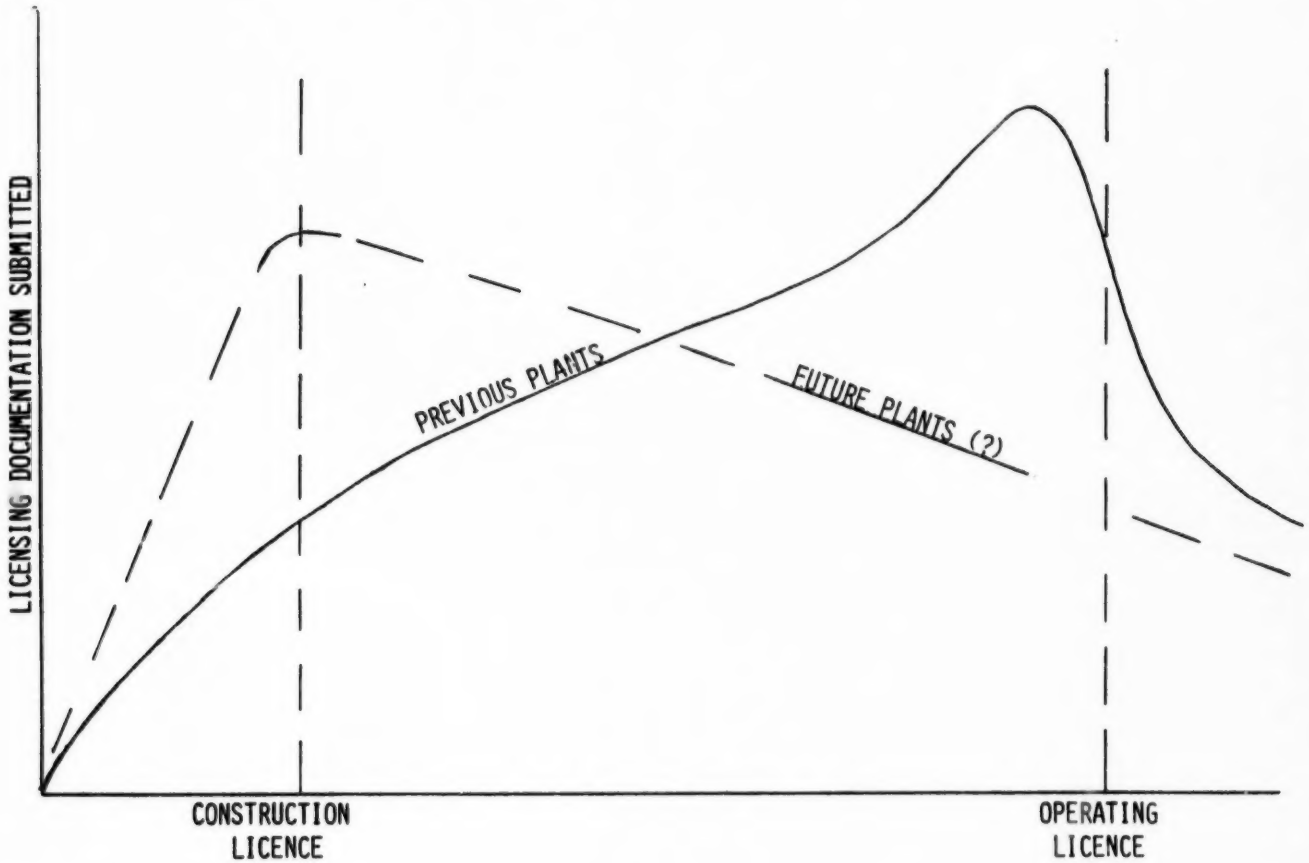

FIGURE 2: LICENSING INFORMATION SUBMITTED FOR CONSTRUCTION AND OPERATING LICENCE